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HIGHLY REDUCING PARTITIONING EXPERIMENTS RELEVANT TO THE PLANET MERCURY

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With the data returned from the MErcury Surface Space ENvironment GEochemistry and Ranging (MESSENGER) mission, there are now numerous constraints on the physical and chemical properties of Mercury, including its surface composition. The high S and low FeO contents observed from MESSENGER on the planet's surface suggests a low oxygen fugacity of the present planetary materials. Estimates of the oxygen fugacity for Mercurian magmas are approximately 3-7 log units below the Iron-Wüstite (Fe-FeO) oxygen buffer, several orders of magnitude more reducing than other terrestrial bodies we have data from such as the Earth, Moon, or Mars. Most of our understanding of elemental partitioning behavior comes from observations made on terrestrial rocks, but Mercury's oxygen fugacity is far outside the conditions of those samples. With limited oxygen available, lithophile elements may instead exhibit chalcophile, halophile, or siderophile behaviors. Furthermore, very few natural samples of rocks that formed under reducing conditions are available in our collections (e.g., enstatite chondrites, achondrites, aubrites). With this limited amount of material, we must perform experiments to determine the elemental partitioning behavior of typically lithophile elements as a function of decreasing oxygen fugacity.

Experiments are being conducted at 4 GPa in an 880-ton multi-anvil press, at temperatures up to 1850°C. The composition of starting materials for the experiments were selected for the final run products to contain metal, silicate melt, and sulfide melt phases. Oxygen fugacity is controlled in the experiments by adding silicon metal to the samples, using the Si-SiO_2 oxygen buffer, which is ~5 log units more reducing than the Fe-FeO oxygen buffer at our temperatures of interest. The target silicate melt compositional is diopside ($CaMgSi_2O_6$) because measured surface compositions indicate partial melting of a pyroxene-rich mantle. Elements detected on Mercury's surface by MESSENGER (K, Na, Fe, Ti, Cl, Al, Cr, Mn, U, Th) and other geochemically relevant elements (P, F, H, N, C, Co, Ni, Mo, Ce, Nd, Sm, Eu, Gd, Dy, Yb) are added to the starting composition at trace abundances (~500 ppm) so that they are close enough to infinite dilution to follow Henry's law of trace elements, and their partitioning behavior can be measured between the metal, silicate, and sulfide phases. The results of these experiments will allow us to assess the thermal and magmatic evolution of the planet Mercury from a geochemical standpoint.